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Pre-AP Chemistry: POPCORN and $PV = nRT$

Purpose: To explore the ideal gas law (to determine the percent water in popcorn, to determine the pressure inside popcorn kernels when they pop) and how it helps make Americans' favorite movie snacks – pop corn!

Introduction

Corn is one of the most common food staples native to the Americas. It appears in many forms: corn on the cob, corn off the cob, creamed corn, and popcorn. field corn or feed corn, which is also fed to livestock, is hung on our doors at Halloween. Each variety of corn contains different amounts of water, sugars, and starches. Popcorn is one of America's favorite movie snacks. So how do you convert a corn kernel into Popcorn? Well, popping popcorn. It involves heating the corn until the *pressure* inside the kernel is great enough to cause it to burst. The burst forms gelatinized starch granules which do not explode, but rather expand into thin, jelly-like bubbles. Neighboring bubbles fuse together and solidify, forming a three-dimensional network much like a sink full of soapsuds. This is the white fluffy solid we eat

Materials

1 Erlenmeyer flasks, 125-mL	1 Utility clamps
1 Graduated cylinders, 10-mL	Weighing dish
2 Wire gauze screens	cooking oil
0.000g or 0.00g Balance	Popcorn or other starch grain, 2-3 brands
1 Ringstand	Barometer
1 Iron rings	
1 Bunson Burners	

Safety

Vegetable oil is flammable. Heat the flask with care.

The flask must be securely fastened to the ring stand with a utility clamp.

Do not eat the popcorn!

Pre Lab Question and Calculations

Corn comes in the form of corn on the cob, corn off the cob, field corn, and popcorn.

1. Based on your current knowledge only, describe how you think pop corn is formed when corn kernels are exposed to heat?
2. What are the differences among these types of corn?
3. What is the pressure of 0.010 mol of water vapor at 200 °C if it occupies a volume of 0.0020 L?
4. Calculate the pressure of the 0.010 mol of water vapor at 150 °C if its volume is held constant at 0.0020 L.
5. What is the relationship between pressure and temperature?

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Procedures

1. Record the mass of a weighing dish.
2. Add 10 kernels of one type of popcorn and reweigh.
3. Calculate the mass of the popcorn kernels.
4. Using the water displacement method, find the volume of the 10 kernels using a 10-mL graduated cylinder. Dry the kernels.
5. Add ~5ml of cooking oil and the 10 kernels to an empty; dry 125-mL Erlenmeyer flask.
6. Determine the mass of the flask, oil, and popcorn.
7. Assemble a ring stand with ring, placing a wire gauze on top of the ring, about 20cm above burner.
8. Using a utility clamp, fasten the flask to the stand so it sits on the wire gauze. **Cover the flask with a piece of wire gauze.**
9. Light the burner and hold the burner, moving it back and forth slowly until the popcorn just begins to pop. Remove the heat when most of the kernels have popped. **Do not burn the popcorn.** If you do, you'll need to start over.
10. If you see water, **NOT OIL**, condensed on the upper part of the flask, heat that part very gently with the burner until it disappears.
11. Let the flask cool, then remove and determine the mass of the flask and contents.
(Remove the metal gauze before weighing.)
12. Thoroughly wash your hands before leaving the laboratory.

Data Table (rewrite on pre-lab so you have more room)

Brand Name	
Mass of kernels + weighing cup (g)	
Mass of weighing cup (g)	
Volume of kernels all 10 (mL)	
Mass of flask, oil, and "unpopped" corn (g)	
Mass of flask, oil and "popped" corn (g)	

Calculated Data

Mass of unpopped kernels (g)	
Average volume of a single kernel (ml)	
Average volume of a single kernel (L)	
Mass of popped kernels (g)	
Mass of water lost (g)	
Moles of water lost (mol)	

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Help with Your Calculations

Percent of water in popcorn = (Mass of water lost)/(Mass of 10 kernels) x 100

** To estimate the pressure of the water vapor at the time of "pop," use $PV = nRT$

Here are some hints regarding this calculation:

Step 1. Rearrange the equation to solve for P.

Step 2. Use the "moles of water lost" from the data table for mole of water.

Step 3. $R = 0.0821 \text{ L atm/(mol K)}$

Step 4. Assume that the popcorn pops at the boiling point of the cooking oil (225 °C) and remember to convert this temperature to kelvins.

Step 5. Use the average volume of the kernel for volume.

Step 6. Pressure will be in **atm**.

Post Questions:

1. Why would some of the kernels not pop.
2. When you heat popcorn, what happens to the water inside the popcorn kernels?
3. Why don't some popcorn kernels pop?
4. What is the purpose of the oil? Propose an explanation of why some popcorn makers/ setups do not need oil.
5. Propose an explanation for how microwave-popping corn works? (Think about what microwave electromagnetic radiation is doing to the water in the kernel). 1-2 paragraphs